Assessing the Effects of Drought and Fire Disturbance in Southern Pine

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Rationale

The terrestrial biosphere is a key component in Earth system processes and interacts with the atmosphere and oceans through complex biogeochemical and biophysical interactions. Recent studies estimate terrestrial ecosystems, including aboveground biomass and soils, store at least 5 times more carbon (C) than currently contained in the atmosphere. Because of the magnitude of terrestrial C stocks, relatively small changes could have a substantial impact on atmospheric C concentrations and therefore alter temperature and climate patterns.

Terrestrial ecosystems of the northern hemisphere, including the Southeastern US, currently act as large sink for atmospheric greenhouse gases (GHGs). Nearly one-third of this C is held in privately owned forests. However, current terrestrial sinks could be converted to C sources due to climate change, resulting in positive feedback loops. A significant increase in climate warming may result in drought related decreases in plant growth and increased risk of severe wildfire, especially if this warming is not accompanied by increases in precipitation.

Results from this project will improve the understanding of terrestrial C dynamics and potential effects of climate driven changes on soil moisture and fire regimes in the Southeastern US. Information will aid land managers in implementing best management practices to increase C sequestration while increasing forests resilience to climate change stressors.

Objectives

Objective 1:

Implement multiple factor experiments to study the complexity and biogeochemistry of soil C dynamics along trajectories of soil moisture/hydrology and fire regimes which are projected under various climate change scenarios (e.g., drier climate) in a prominent Southeastern pine ecosystems (FL).

Objective 2:

Investigate the disturbance effects of fire on the structure and function of C stocks in pine ecosystems, including above and belowground components. Increased warming and drought conditions are expected to increase in the southeast, as such, the risk of severe wildfire is likely to increase as well. This research will exemplify the response of C budgets to changing fire regimes.

Objective 3:

Compliment 3PG modeling efforts from Aim 2 by upscaling information from Tier 3 sites and other resources to simulate the response of terrestrial ecosystems to various climate scenarios with LPJ - Dynamic Global Vegetation Model (DGVM). LPJ simulates plant biogeography and plant/soil biogeochemistry at a level of intermediate complexity suited for regional to global scale analysis. Climate, soil and atmospheric information are used for input. LPJ simulates spatially explicit transient vegetation composition according to plant functional groups, as well as photosynthesis, mortality, decomposition, wildfire and water and carbon budgets.

Hypotheses

We will investigate the following overarching hypotheses motivated by research questions:

How will increasing temperatures and changes in soil moisture dynamics conditioned by global climate change impact terrestrial C (active, recalcitrant, total soil C and aboveground biomass C pools)?

Hypothesis 1:

Moisture effects are more pronounced to foster significant change in soil C in southern pine ecosystems than temperature effects induced by climate change.

Research Question 1 (RQ 1): How permanent is the soil C sink in southern pine forest under increased fire frequencies conditioned by climate change effects in the future?

Hypothesis 2:

Moisture effects on disturbance regimes, primarily fire, and the resulting impact of disturbance on C cycling is likely to be greater than direct effects of moisture on net ecosystem C storage at both plot and regional scale.

RQ 2: Which factors impart control on scale-dependent behavior to assess soil C stocks and pools across large regions?

Hypothesis 3:

Terrestrial ecosystem systems of the Southeastern US will become a net source of C under a scenario of increased temperature and decreased precipitation.

RQ 3: What is the effect of climate change, such as increased temperatures and decreased precipitation, on terrestrial C pools of the Southeastern US?

Study Area

Objective 1:

Soil profiles will be pooled from PINEMAP tier sites and other projects across the Southeastern US to investigate relationships between soil moisture, fire and SOC.

Objective 2:

Plots in Austin Carey Memorial Forest will be used to assess the effects of varying fire regimes on the structure and function of terrestrial C stocks.

Objective 3:

Various data inputs, including flow direction, slope, topographic wetness index (TWI), elevation, land cover, etc., will be used as model inputs and scaled up to the Southeastern US.

Remarks:

This project will be complemented by soil C, and remote sensing-derived spectral data from other sources and research projects. Data from several tier sites will be synthesized to populate C simulation models and/or verify model output.

Example Data Inputs for GEFSOC